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POSTMORTEM CORONARY ATHEROSCLEROSIS FINDINGS IN
GENERAL AVIATION ACCIDENT PILOT FATALITIES:
1975-1977

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16. Abstract The autopsies of 764 pilots involved in fatal general aviation accidents during the years 1975-1977 were reviewed to appraise the age specific prevalence of coronary atherosclerosis among the autopsied group. Fifty-one percent of the pilots killed in aircraft accidents and autopsied during 1975-77 were found to have some degree of coronary atherosclerosis ranging from minimal to severe. However, only about 5 percent of the autopsied group were categorized as having severe coronary atherosclerosis. The rate per 1,000 of severe coronary atherosclerosis increased with age from 14.5 for ages less than 30 to 89.9 for ages 50 years and above, with the rate nearly tripling from ages 30-39 to 40-49 (22.1 to 63.6). While the findings of this study are consistent with, and do parallel, the findings of other recent autopsy studies, the prevalence of coronary atherosclerosis among this group of autopsied airmen is less than would have been expected based on the results of these other studies. A					
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INTRODUCTION

It is well known that cardiovascular disease is the leading cause of death and a significant cause of sudden incapacitation in the United States today. Because sudden incapacitation and sudden death are frequently the first and only manifestations of coronary atherosclerosis, it is of utmost importance, not only to the airman, but to the Federal Aviation Administration (FAA) that cardiovascular disease that could lead to sudden incapacitation be detected early. To that end, FAA screening programs and airman and Aviation Medical Examiner educational programs emphasize the importance of early cardiovascular disease detection. Cardiovascular disease represents the leading cause for denial of medical certification to airman applicants, accounting for over a third of denials for all causes.

Autopsies for 764 pilots involved in fatal general aviation accidents during the years 1975 through 1977 were reviewed to appraise the age specific prevalence of coronary atherosclerosis among the autopsied group.

BACKGROUND AND METHODS

Coronary atherosclerosis is an extremely common form of simple intimal arteriosclerosis in which deposits of yellowish plaques containing cholesterol, lipoid material, and lipophages are found within the intima and inner media of large and medium-sized arteries. There are four visual gradings of coronary atherosclerosis: namely, fatty streak, fibrous plaque, complicated lesion, and calcification. The fatty streak is any intimal lesion that is distinctly stained by a fat-soluble dye and does not show any other type of cellular change. The fibrous plaque is a firm, elevated intimal lesion which, in the fresh state, is pale gray, glistening, and translucent. A complicated atherosclerotic lesion is one in which there is ulceration, hemorrhage, or thrombosis with or without calcium deposits. And finally, the calcified lesion is an area where calcium deposition is detectable (visually or by palpation) without overlying hemorrhage, ulceration, or thrombosis.

As in most chronic diseases, the etiology of coronary atherosclerosis is complex and multifactorial; the three strongest risk factors for coronary atherosclerosis appear to be hyperlipidemia, hypertension, and smoking. Diet seems to

play a major role in the disease process. Diets high in saturated fats predispose to hyperlipidemia; it has been noted that this disease correlates well with the percent of fat intake in the total diet. The levels of triglycerides in the blood have been associated with an increased risk to coronary atherosclerosis. Prolonged periods of excessive external stress and the increased intake of alcohol raise the level of blood lipids.

Relatively little is known about the contribution of cardiovascular disease to aviation accidents. While the potential for accident outcome has been recognized for some time by the aviation medical community, attention has centered mostly on the commercial or air transport category pilot and research concerning the general aviation segment of the population has been scarce. Some recent research efforts have, however, focused attention on the significant potential for interaction between existing cardiovascular disease and aircraft accidents (1-7). Pettyjohn and McMeekin found coronary artery disease present to some extent at autopsy in about 87 percent of a 20- to 34-year-old military pilot group with 17 percent classified as moderate and severe (6). Mason's study of preexisting disease and aircraft accidents among United Kingdom aviators found a prevalence of coronary artery disease amounting to 62 percent for a group of British military and civilian pilots killed while flying with 24 percent classified as having more than 50 percent luminal restriction (3). In a later article, Mason discusses some interactions between trauma and previous disease which may present difficulties in interpretation with specific reference to coronary disease. Mason points out that severe cardiac damage, a frequent feature of aircraft accidents, may have resulted in conservative interpretation and underestimation of the importance of coronary disease in fatal general aviation accidents (4).

Autopsy reports for United States civilian general aviation accidents are received, maintained, and reviewed by the Medical Statistical Section, Civil Aeromedical Institute, Federal Aviation Administration in Oklahoma City, Oklahoma.

For the 3 years studied, 764 pilot autopsy reports were received by the Medical Statistical Section. The total number of fatal aviation accidents was 2,003 for the 3 years, 1975-77, which yields an autopsy rate in excess of 38 percent considering that not all fatal aircraft accidents involve pilot fatalities.

After reviewing the literature and consulting with several pathologists, we concluded that no uniform classification of coronary atherosclerosis exists. Therefore, it was necessary to establish a working classification which would incorporate the variety of findings contained on the autopsy records which are received.

The Armed Forces Institute of Pathology uses a four-category classification system for coronary atherosclerosis. Their classification is as follows:

- 1) Grade I : <26% luminal occlusion
- 2) Grade II : 26-50% luminal occlusion
- 3) Grade III: 51-75% luminal occlusion
- 4) Grade IV : >75% luminal occlusion

Since we did not feel the autopsy data we were analyzing warranted this degree of accuracy in interpretation, and because most pathologists use a three-category system with expressions of mild, moderate, and severe, or a percentage expression of luminal occlusion, a three-category classification system based on degree of luminal occlusion was formulated as follows:

- 1) Grade I : <33% luminal occlusion
- 2) Grade II : 33-66% luminal occlusion
- 3) Grade III: >66% luminal occlusion

Such terms as "few atheromatous plaques," "no significant atherosclerosis," and "minimal atherosclerosis" were placed into the Grade I category. When a pathologist simply stated "moderate" or "severe" atherosclerosis with no percentage figures, the cases were placed in Grade II and Grade III respectively. Whenever the pathologist used combinations such as "minimum-moderate," "moderate-severe," or "moderately severe" atherosclerosis, the lower category was recorded; for example, Grade II was recorded for "moderate-severe" atherosclerosis. Similar rationale was used for percentage figures; for example, 60-70 percent occlusion was recorded as Grade II. In all cases, the percentage figure took priority over the descriptive term; for example, moderate atherosclerosis with 30 percent occlusion was recorded as Grade I. Recording the lower category and giving priority to the percentage no doubt resulted in a more conservative estimate of the prevalence of coronary atherosclerosis by grade in this study.

RESULTS AND DISCUSSION

Of the 764 autopsied airmen in this study, 94 could not be classified as to presence or absence of coronary atherosclerosis due to incineration or traumatic destruction of the heart. After removing these 94 "unknown" cases, no coronary atherosclerosis was found in 49.1 percent of the remaining autopsied cases. The prevalence of coronary atherosclerosis to any extent, regardless of how minor, among those airmen who came to autopsy as a result of a fatal general aviation aircraft accident during the years 1975-77 was 50.9 percent (Figure 1).

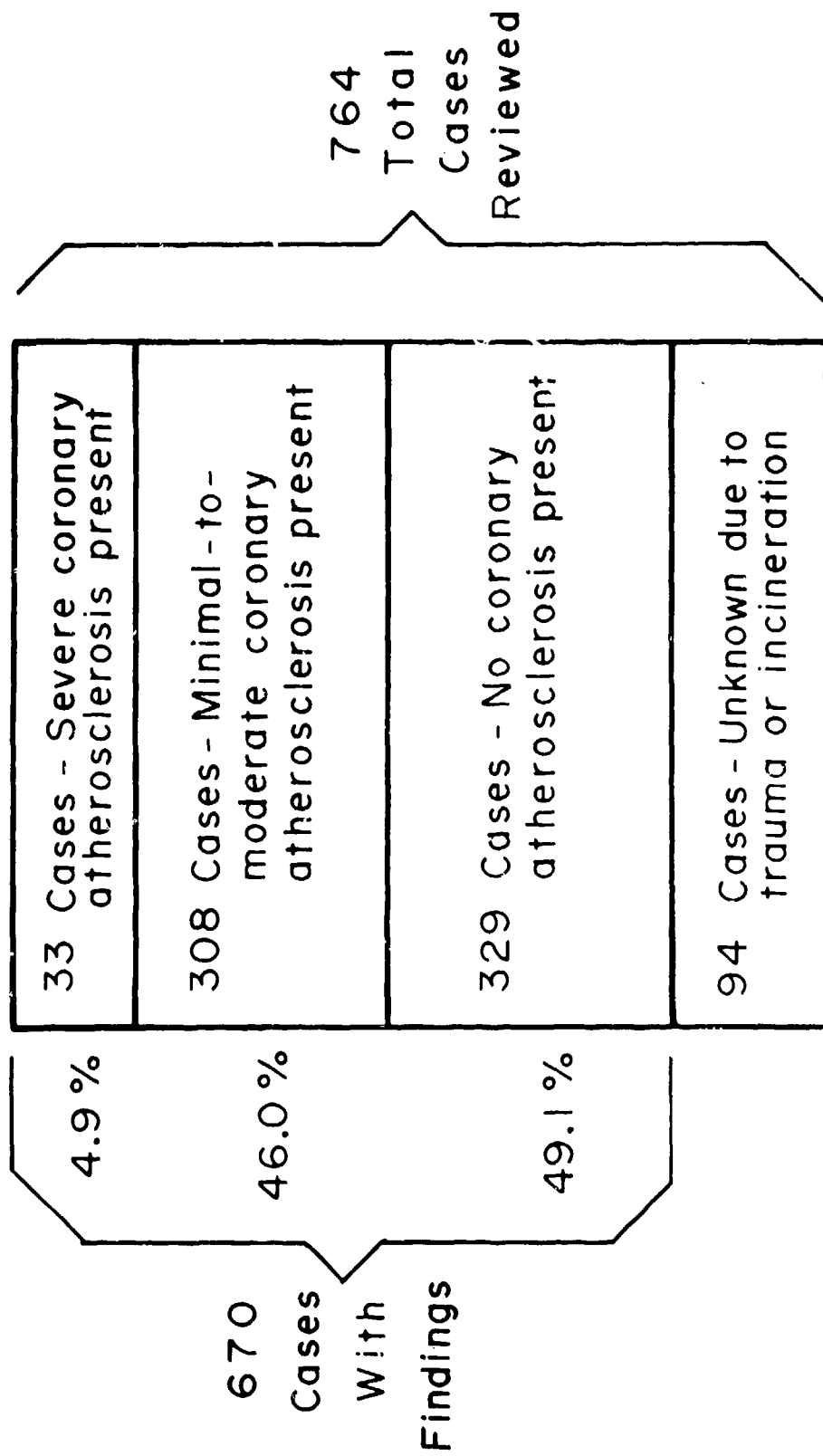


Fig. 1. Postmortem coronary atherosclerosis findings in general aviation accident pilot fatalities 1975-77.

Severe coronary atherosclerosis, implying at least a two-thirds luminal narrowing, was found in 4.9 percent of the cases (or an average of 11 cases per year). Obviously these prevalence findings are of the greatest concern since they represent those most likely to have been subject to sudden incapacitation. However, positive statements regarding sudden incapacitations due to cardiovascular disease were noted in only 15 instances or about 5 per year. The age specific rates of coronary atherosclerosis at autopsy found among the group of airmen studied yields results consistent with previous findings (1-7). The rates for minimal-to-moderate involvement show a consistent, linear increase with age. A fourfold increase in the prevalence of severe coronary atherosclerosis is observed between age intervals 30-39 and 50-and-above. The biggest increase between sequential age intervals is observed between age intervals 30-39 and 40-49, where an approximate threefold increase is seen. Again, this is consistent with known patterns of substantial increase in the incidence of cardiovascular disease beginning at age 40 (Table I and Figures 2 and 3).

There is no reason to believe that the pilots autopsied were a select group. A review of individual accident cases does not suggest a consistent bias. Further, results are inconsequentially different for the 3 separate years we have been accumulating data. While it is true that a few well-publicized accidents are likely to receive intensive investigation due to air-to-ground communications, the discovery of selected medications at the scene of the accident, and other isolated factors suggestive of in-flight incapacitation, such instances are rare and would have minimal effect on summary data. Some other factors determining whether an autopsy is performed are: the location and circumstances of the accident; availability of a pathologist and facilities; cooperation of the local coroner or medical examiner; and how actively the accident investigation program is pursued in an FAA region.

The autopsies were performed by various medical examiners, hospital pathologists, and forensic pathologists. Reports varied greatly with regard to the length, completeness, detail, and description. These limitations were necessarily considered in the accumulation and presentation of findings.

CONCLUSIONS

While the findings of this study are indicative of a recognized epidemic of cardiovascular disease in the U.S. population, it is noteworthy that prevalence of coronary atherosclerosis observed in the FAA-autopsied cases studied is less than that observed in other aviation groups studied. Part of the reason

TABLE I. AGE DISTRIBUTION OF 1975-77 FATAL GENERAL AVIATION
ACCIDENT VICTIMS WITH AND WITHOUT CORONARY ATHEROSCLEROSIS

Age Group (yr)	No Coronary Atherosclerosis		Minimal-to- Moderate		Severe		Total	
	Frequency	Percent	Frequency	Percent	Frequency	Percent	Frequency	Percent
<30	104	31.6	32	10.4	2	6.1	138	20.6
30-39	107	32.5	70	22.7	4	12.1	181	27.0
40-49	70	21.3	92	29.9	11	33.3	173	25.8
50 and above	48	14.6	114	37.0	16	48.5	178	26.6
TOTAL	329	100.0	308	100.0	33	100.0	670	100.0
Percent	49.1		46.0		4.9		100.0	

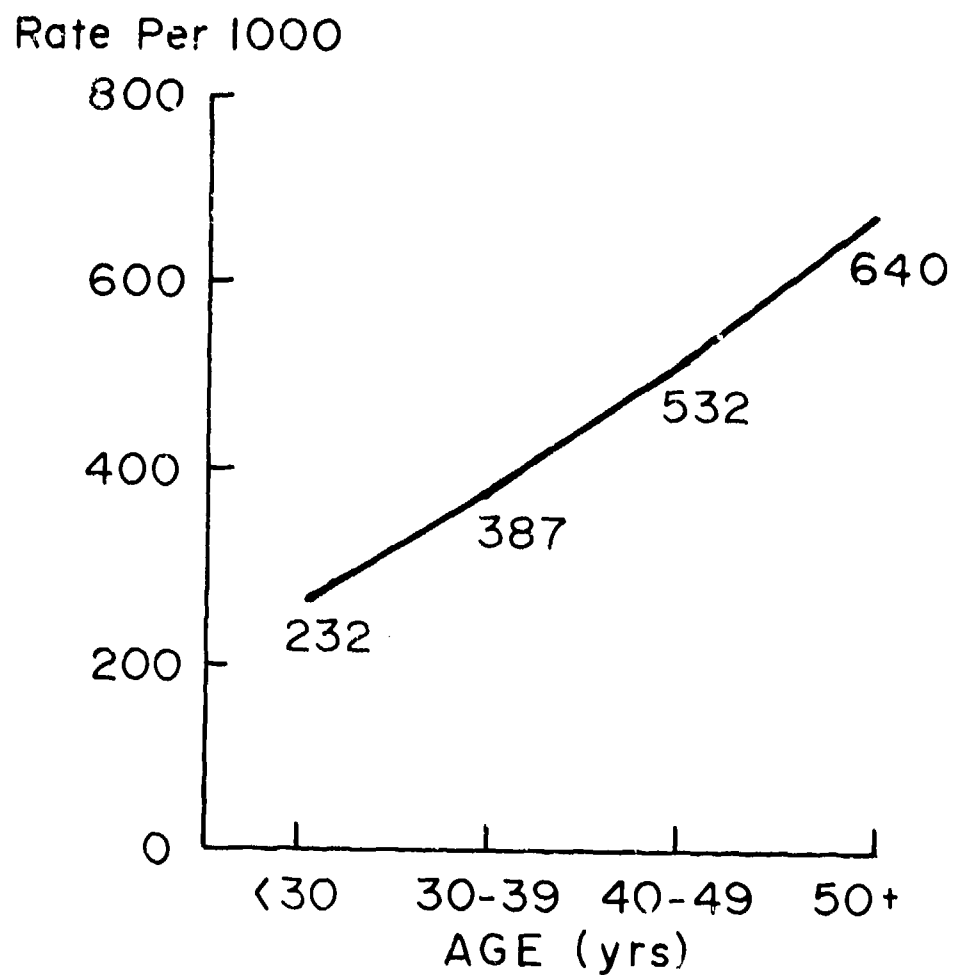


Fig. 2. Age specific rates of minimal/moderate coronary atherosclerosis among 1975-77 fatal general aviation accident pilots.

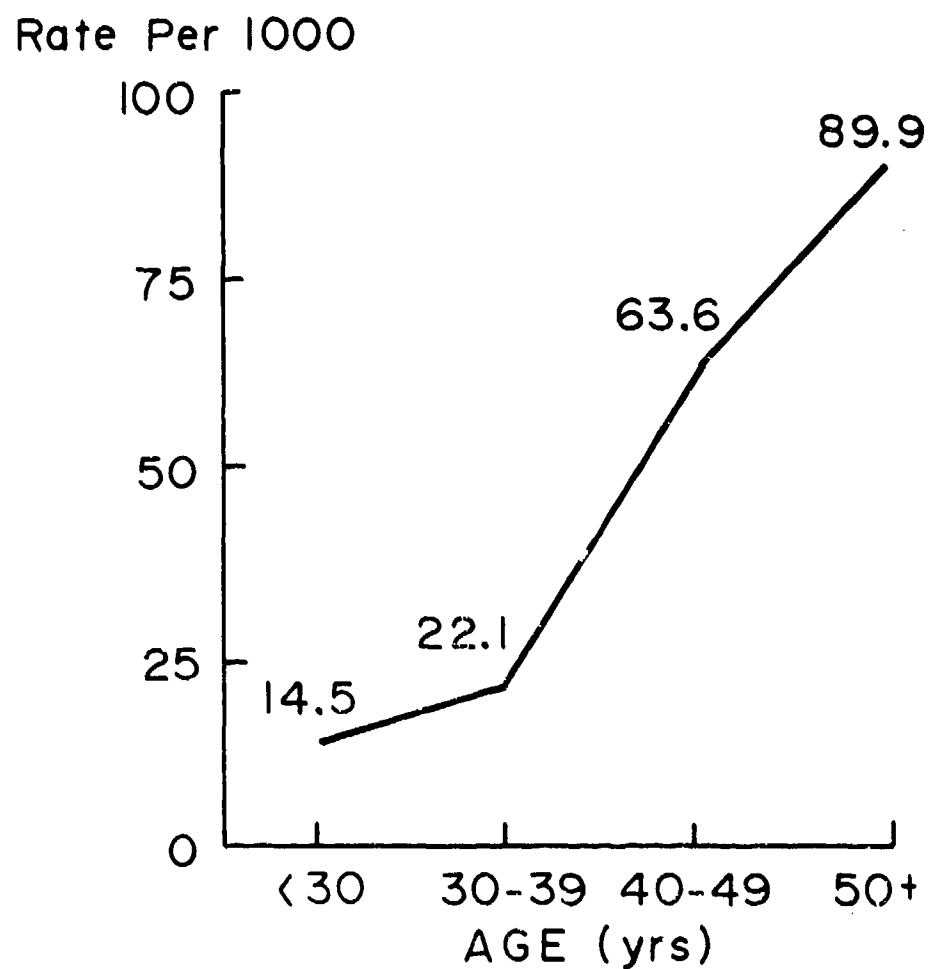


Fig. 3. Age specific rates of severe coronary atherosclerosis among 1975-77 fatal general aviation accident pilots.

for this observation has to do with the way autopsy data are accumulated in this program. Efforts are currently underway to standardize autopsy findings for general aviation accident victims. However, the magnitude of the differences observed is not likely accounted for by the deficiency in autopsy reporting. Continued vigilance is obviously called for in screening and education of airmen and Aviation Medical Examiners. Particular attention should be given to ages 40 and above. However, it seems unlikely that the low prevalence of severe coronary atherosclerosis could be reduced significantly by the addition of classical diagnostic techniques as routine screening measures, given the recognized problems of these procedures with regard to sensitivity and specificity. Such procedures obviously continue to be important when indicated by history or other findings.

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